Larvivorous Fishes in Mosquito Control

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Cover: Mass production of *Gambusia affinis*
Source: **Dr. M.S. Malhotra**

BACKGROUND

Larvivorous fishes were used extensively to control mosquito breeding before the advent of DDT. *Poecilia reticulata* was imported in India in 1908 for the control of mosquito breeding. *Gambusia affinis* was imported in India from Italy in 1928. These two fishes are now widespread in the country. Unfortunately during the DDT era, use of larvivorous fishes in malaria control diminished. However, during late sixties resurgence of malaria started, and in 1976 National Malaria Eradication Programme (NMEP) reported 6.5 million malaria parasite positive cases in the country. By this time repeated DDT spraying produced resistant mosquitoes, and spraying also resulted in adverse impact on the environment. In many areas although spraying was ongoing but malaria cases did not go down. With this background Malaria Research Centre conceptualized and launched the bioenvironmental control of malaria in several endemic locations in the country. Among the biological control agents, larvivorous fishes were the chief mosquito control agents.

Larvivorous fishes offer many advantages in mosquito control. These are:

(i) Fishes provide long-term effective control of mosquito breeding,

(ii) Use of fish in mosquito control is cost-effective,

(iii) Safety to environment,

(iv) Technology of mass production and distribution of fishes is simple and fishes can be spread throughout the country at low cost,

(v) Larvivorous fish culture can be linked with edible fish production and thus increase income in villages, and

(vi) Fishes provide control of a variety of mosquitoes.

CHARACTERISTICS OF LARVIVOROUS FISHES

- Larvivorous fishes should be small in size to be able to penetrate into weeds and shallow waters,
- Should be hardy to withstand water turbidity, pH and pollution,
- Should withstand packaging and transportation,
- Should breed profusely throughout the year,
- Should be of no food value,
- Should not be attractive, and escape quickly from the predators,
- Should be surface feeders,

- Should preferentially feed on mosquitoes, and
- Should survive by consuming diverse food in absence of mosquito larvae.

BIOLOGY AND POTENTIAL OF IMPORTANT LARVIVOROUS FISHES

1. *Gambusia affinis* (Mosquito fish)

Body cylindrical and compressed, colour uniform grey green. Size : Females 6 cms and males 3.5 cms, (Fig.1). Feeds on aquatic insects. Show preference to mosqutio larvae. Breeds prolifically. 35 to 80 young ones are born after a gestation period of 7 to 15 days. Breeds at least 3 times in a year. *Gambusia* was produced in billions in the ponds of Haldwani and Shahjahanpur field stations of Malaria Research Centre between 1986 - 91.

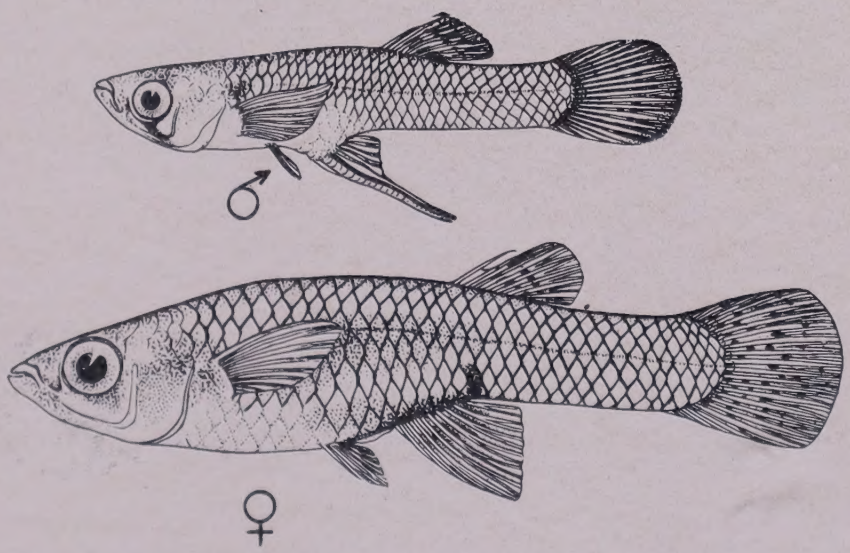


Fig. 1: Gambusia affinis

This fish is tolerant to salinity and resistant to organic pollution. Preferred temperature range is 10–35 deg. C., but it can withstand freezing temperatures. Ideal for controlling *Anopheles* and *Culex* mosquitoes in ponds, wells and streams throughout India (Figs. 7 & 9).

2. *Poecilia reticulata* (Guppy)

Females of this species resemble *Gambusia*. Males are brightly coloured. Size: females 4 cms, males 2 cms. It cannot tolerate low temperature i.e., less than 10 deg. C. Optimum temperature requirement is between 22 - 24 deg.C. Guppy is a prolific breeder, at a time gives birth to several hundreds of offsprings and breeds four times a year. Guppy tolerate pollution better than *Gambusia*. Harmless to aquatic fauna and flora. Suitable for controlling *Culex* and *Anopheles* mosquitoes in ponds, streams and drains (Fig. 2). This

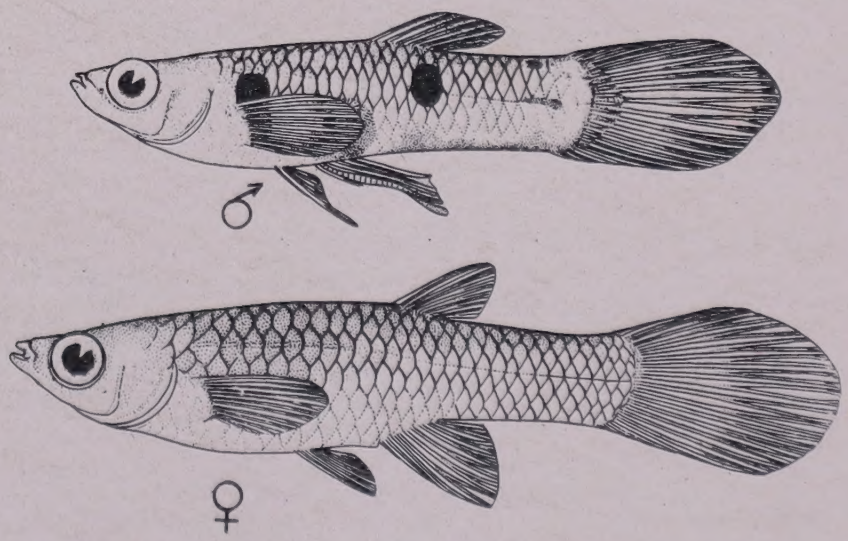


Fig. 2: Poecilia reticulata

fish was mass produced by MRC field stations in the village ponds of Nadiad and Shahjahanpur. It was so abundantly produced that there was frequent need of thinning Guppy population from the ponds. It is distributed in Central and South India and patchy distribution in North India.

3. *Danio rerio*

Body compressed. Four blue lines on the sides and tail fin. Three longitudinal bands on anal fin Size: 5 cms (Fig. 3). Surface feeder. Suitable for slow moving streams with grassy margins, ponds, shallow earth wells, seepages, and rice fields. Poor tolerance to pollution and salinity. Breeds

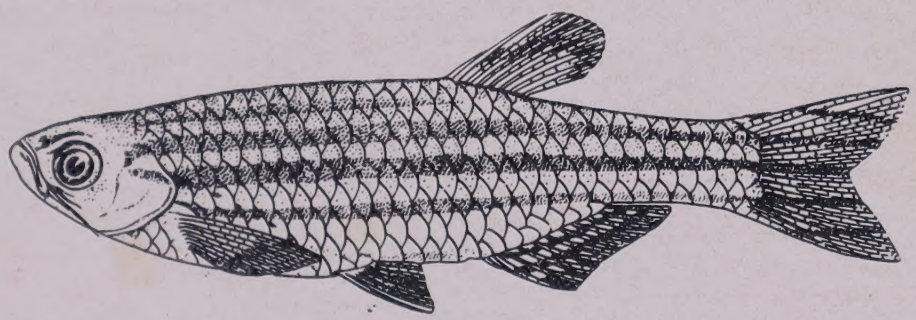


Fig. 3: Danio rerio

during monsoon. Range of temperature 10–40 deg. C. Controls *Anopheles* and *Culex* mosquitoes. It was successfully used to control mosquitoes in Rourkela, Orissa. Table 1 shows the impact of *Danio* in reducing larval density in rice fields. Distributed all over India.

4. *Aplocheilus panchax*

Females are smaller and colourless. A third eye-like shining silvery spot on the middle of the head. Size : 9 cms (Fig. 4). These fishes are active and inhabit clear, shallow, fresh and brackish water at low altitudes. Lakes and pools are favoured habitats. It is not resistant to pollution and salinity. Eggs are laid on aquatic plants. Matures when half grown in about four months. Breeds throughout the year laying about 500 eggs in three months. Suitable for paddy fields, wells, marshes and lagoons. Effectively controls *Anopheles*. This species is widely distributed in India.

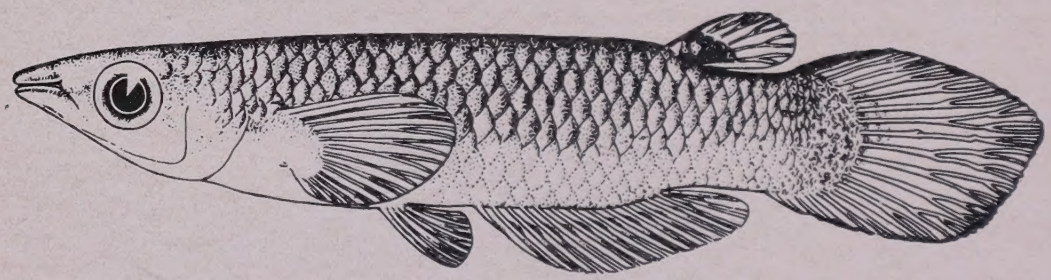


Fig. 4: Aplocheilus panchax

5. *Oryzias melastigma*

Small mouth, strongly compressed body and narrow upper jaw. Male is longer than the female. Size : 4 cms (Fig. 5). Though brackish water and estuarine fish, it also inhabits fresh water ponds, lakes, rivers, canals and creeks. 20 to 40 eggs are carried by the females until they are hatched. Year round breeding. Surface feeder. Suitable for

Fig. 5: Oryzias melastigma

open shallow waters like paddy fields. Controls *Anopheles* and *Culex*. Impact of this fish in successfully controlling mosquito breeding in paddy fields is summarized in Table 1. It is widely distributed in Bengal, Orissa and Tamil Nadu.

6. Tilapia mossambica

Size : 15 - 20 cms (Fig. 6). Year round breeder, suitable for stagnant water and marshes. Highly resistant to organic pollution, tolerant to salin-

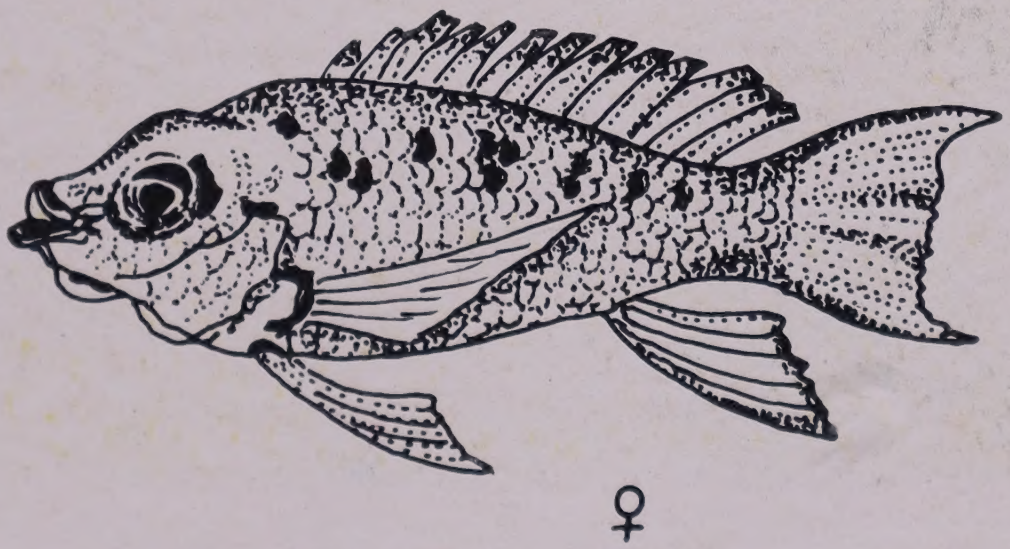
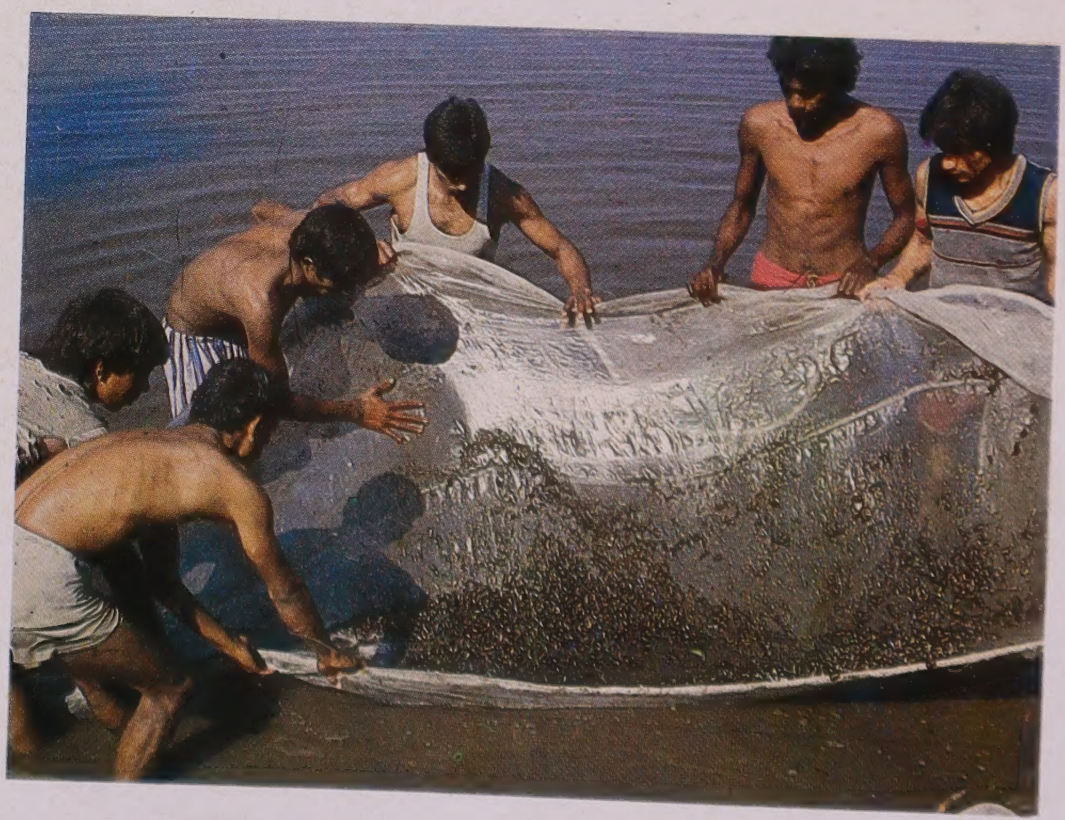


Fig. 6: Tilapia mossambica

ity. Maximum range of temperature 10-40 deg. C. It is used for food. Controls *Culex* breeding and is distributed in South India.

PROPAGATION IN VILLAGE PONDS

In almost every village there are some fresh water ponds which are big and deep. These ponds have a great potential for fish culture and can very well be utilized for propagation of larvivorous fishes for vector control. Usually the village ponds are not maintained properly which leads to dense growth of aquatic weeds. Secondly, organic debris at the bottom results in creating suitable



Collection of *Gambusia affinis*

Gambusia affinis lays 40 to 60 young ones at a time

conditions for predatory and weed fishes. To make such ponds suitable for propagation of larvivorous fishes, they are drained and desilted. The excavated silt is used for repairing and raising embankment. All plant weeds are removed and the pond is refilled with water.

Initially a dose of 1000 kg of cattle manure per hectare can be applied. After a fortnight, pond becomes ready for introduction of larvivorous fishes. Depending on the size of the pond, live female and males of desired larvivorous fishes are introduced in the pond. In the medium sized

pond about 1000 females and 500 males are introduced. Under normal conditions within a few months fishes become abundant. *Gambusia* and Guppy can be easily propagated in this manner in village ponds. The periodical thinning of fishes is recommended. Domesticated animals and wild life can use water of these ponds. These ponds can also be used for the production of edible fishes (carps).

FIELD APPLICATION

Ponds: Small and big ponds are very common in villages. Bigger ponds are mostly permanent and

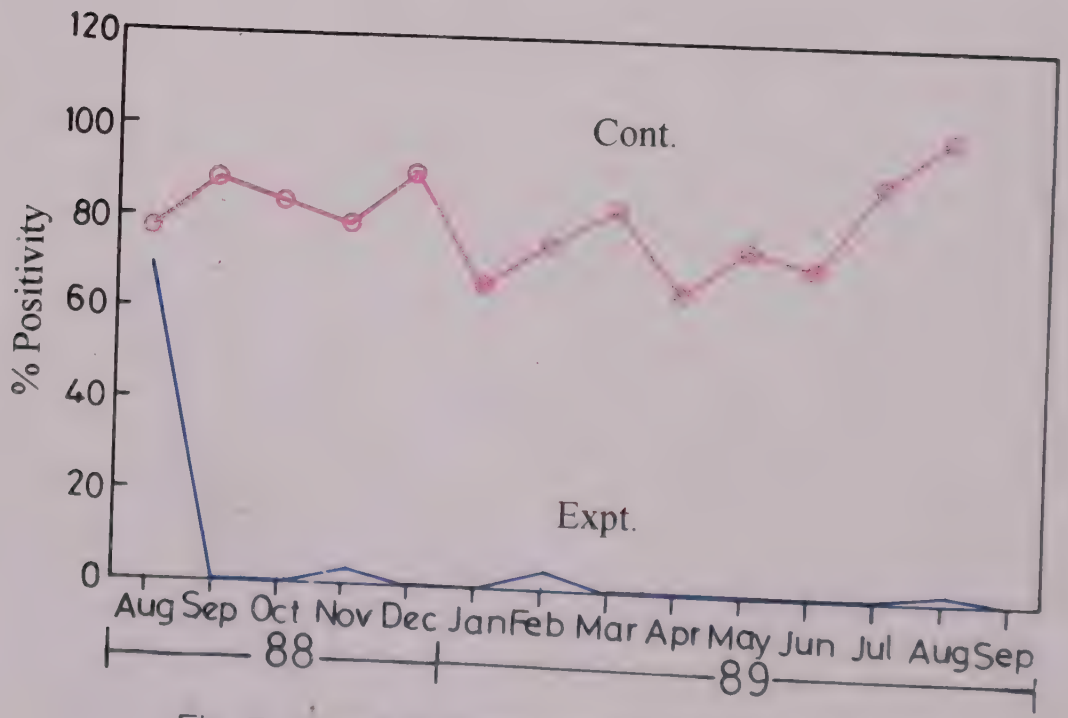


Fig. 7: Impact of *Gambusia* on density of III & IV instar larvae and pupae in ponds

fed by canal water or tube-well. However, smaller ponds dry up in summer months if there is no water supply. These ponds usually have submerged and floating aquatic vegetation at the shorelines which are the places where mosquitoes breed.

Malaria vector *An. culicifacies* also breeds in ponds. *Gambusia affinis* was able to control mosquito breeding in ponds due to its smaller size enabling it to negotiate vegetation in the shallow periphery water and devour mosquito larvae. In Hardwar only 3% ponds with *Gambusia affinis* supported mosquito breeding as against 55% ponds without fishes in Fig. 7.

Wells and Overhead Tanks: *Anopheles stephensi*, is the principal vector of urban malaria in India. This mosquito breeds in wells, sumps and overhead tanks. Studies carried out in Madras revealed that *G. affinis* successfully controlled the breeding of *An. stephensi* in 3,000 overhead tanks and 2,400 wells during 1987-91 (Fig. 8). In Shahjahanpur, (North India), only 5% wells with *Gambusia* were breeding for mosquitoes as against 60 to 80% wells in control areas (Fig. 9).

Rice fields: Paddy plantation coincides with transmission season of malaria in many parts of India. Rice fields are shallow mosquito breeding sites. Though culicine mosquitoes breed abun-

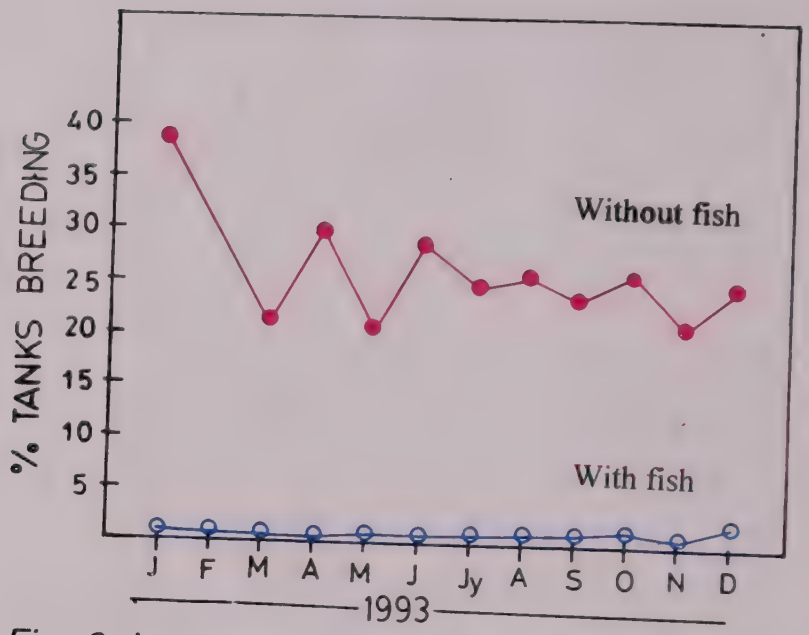


Fig. 8: Impact of *Gambusia* in controlling *An. stephensi* in over head tanks in Madras

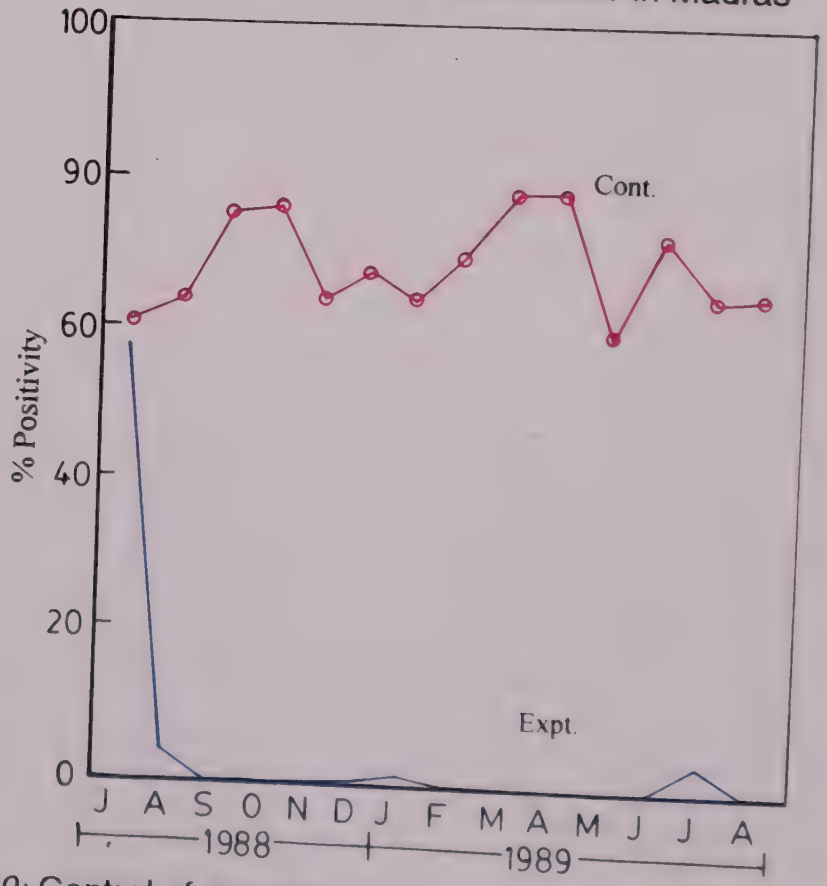


Fig. 9: Control of mosquito breeding by *Gambusia affinis* in wells

dantly in rice fields, the breeding of *An. culicifacies* may also be substantial. Fishes suitable for this type of habitat are *Danio* (*Brachydanio*) *rerio* and *Oryzias melastigma*. *D. rerio* reduced density of mosquito larvae by 86.8% in Sundergarh, Orissa on 6th day post-application (Fig. 10). Similarly, *Oryzias* reduced the densities of mosquito larvae by 76% on 6th day of introduction. On subsequent days 92 to 100% reduction was achieved (Table 1).

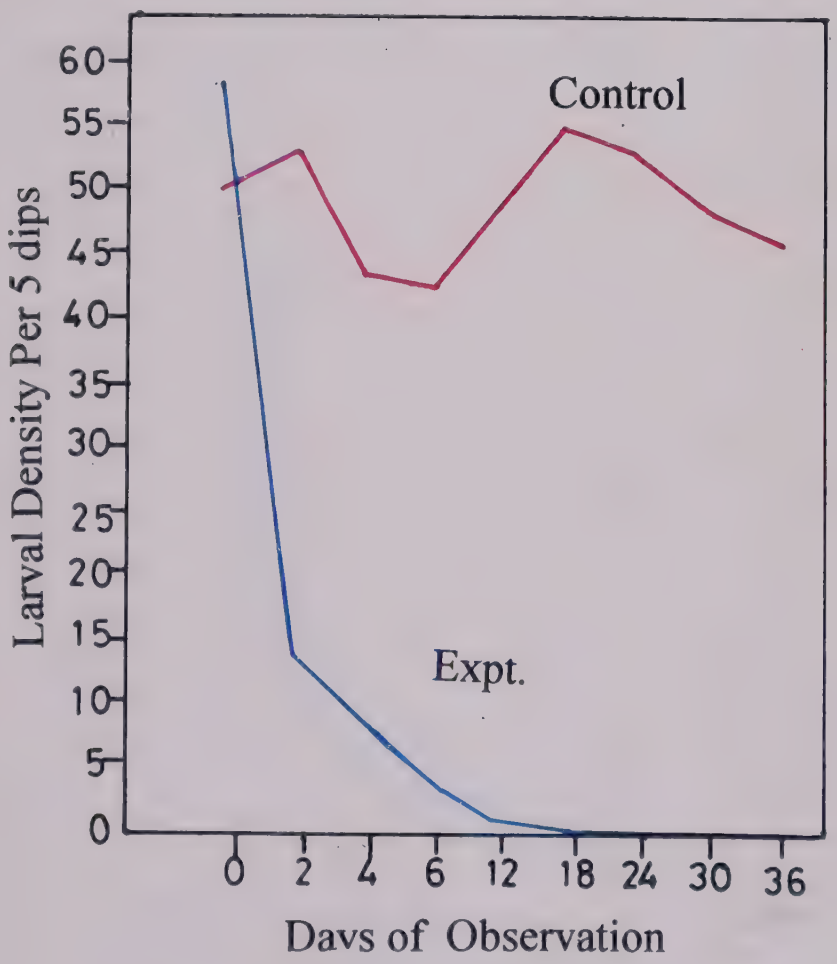


Fig. 10: Impact of *Gambusia affinis* on mosquito breeding in rice fields

Table 1. Impact of *Danio rerio* and *Oryzias melastigma* in controlling mosquito breeding in rice fields

Day	Densiy of larvae per 5 dips				Control (without fishes)
	Experimental (with fishes)				
	Danio		*Oryzias*		No. of larvae
	No. of larvae	% reduc-tion	No. of larvae	% reduc-tion	
0	29.6	–	13.7	–	15.6
2	5.3	47.8	4.6	1.2	5.3
4	5.1	78.1	7.7	28.7	12.3
6	3.6	86.8	3.0	76.2	14.4
12	3.0	92.4	0.3	98.3	20.7
18	1.0	97	0	100	18.0
24	0.3	99.1	0	100	28.3
30	0.3	99.3	0	100	22.1
36	0.6	98.1	0	100	16.7
42	0.3	99.3	0	100	23

Drains: Drains are permanent breeding sites. *Culex quinquefasciatus* mostly breeds in drains which have polluted water. *Poecilia reticulata* is the fish of choice for drains. It can tolerate organic and inorganic pollution and proliferates satisfactorily in drains. *P. reticulata* has been successfully used in Hardwar, U.P. (Fig. 11) and Panjim Goa to control *Culex* breeding.

Use of *Poecilia* in drains

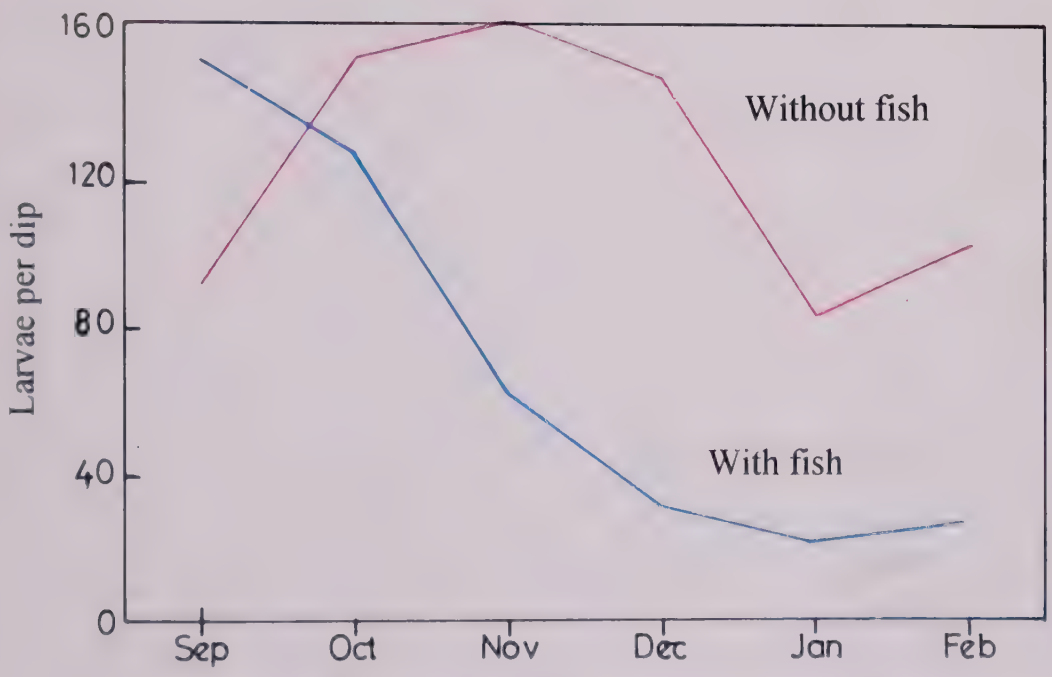


Fig. 11: Impact of Guppy in controlling *Culex* mosquitoes in drains

INCOME GENERATION

Studies carried out in Nadiad and Shahjahanpur showed that Guppy, common carps, major carps and prawns could be grown together in village ponds, thereby generating income for village development. Fish production along with Guppy was successfully carried out in 8 village ponds after introducing fingerlings and fries of common and major carps and juvenile prawns.

METHOD OF INTRODUCTION OF FISHES IN NEW AREAS

Packaging: Fishes can be safely transported in polythene bags half filled with water and half with oxygen. Bags should be tightly secured on top and each bag may contain 25 to 30 fishes. Bags can be placed in card board or thermocol boxes or biscuit tins of size 45 x 45 x 45 cms and transported by road or air.

Transportation: The boxes/tins should be transported quickly to their destination, preferably in night so as to avoid high temperature of day. Wherever possible, fishes should be sent by air to far off places. To avoid morfality during transportation, oxygen may be replenished in the plastic bags at 6 to 8 hr interval. Short distance transportation should be carried out either in earthen pots or in polythene bags half filled with air (if oxygen is not available). Help from local

Transportation of larvivorous fishes

state fisheries departments can also be sought to transport fish.

After care: In the absence of mosquito larvae, alternative food (zooplankton) like *Daphnia*, *Cyclops* etc. should be available. *Gambusia* and Guppy usually do not need much care.

Predators: Common predators of *Gambusia* and Guppy are carnivorous fishes like *Ophiocephalus*, *Mystus* and *Wallago* spp., which take a large chunk of larvivorous fishes, if not removed from ponds prior to introduction, However, *Gambusia* and Guppy populations are least affected owing to their fast multiplication rate.

ECO-SAFETY FROM EXOTIC FISHES

Though *Gambusia affinis* and Guppy have been able to disperse themselves in Indian waters after their import to India, they have not dominated over Indian fishes. Studies carried out in Haldwani and Shahjahanpur revealed that there are natural predators and pathogens of these fishes. Extreme temperature, water currents and floods also play important part in destabilizing them. After widespread floods in Shahjahanpur during 1991, most of the *Gambusia* fishes were washed away from mass production ponds. A survey carried out after the floods indicated that out of 116 different sites observed in canals only

Culture of *Gambusia* with carps

6 sites showed the presence of *Gambusia* and out of 88 ponds surveyed *Gambusia* was found only in 7 ponds. Not a single *Gambusia* was found in 5 rivers.

APPLICATION IN MALARIA CONTROL

- Fishes provide mosquito control at low cost, without any adverse effect on the environment and produce long lasting effect in suppressing mosquito proliferation.
- To link up mosquito control with income generating schemes, village ponds could be used for larvivorous and edible fish production.
- Larvivorous fish production can also be linked up with inland fisheries programme.
- Fishes have tremendous scope in fighting irrigation, urban and rural malaria.
- Larvivorous fishes provide environmentally safe, long-term, effective and sustainable mosquito control.
- Various species of larvivorous fishes were introduced, propagated, mass produced and successfully used in several field stations of Malaria Research Centre located in different places in India.
- Fishes most suitable for various habitats are shown in Table 2.

Table 2: Suitable fishes for various habitats

Water bodies	Fishes most suitable	Mosquito species controlled
Ponds	*Gambusia affinis*	*Anopheles Culex*
Wells	*Gambusia affinis*, *Guppy Aplocheilus*	*Anopheles*, *Culex*
Paddy fields	*Danio rerio Aplocheilus panchax Oryzias melastigma*	*Anopheles*, *Culex*
Drains	Guppy	*Culex*
Polluted waters	*Tilapia mossambica* Guppy	*Culex*
Saline and alkaline waters	*Oryzias melastigma Aplocheilus*	*Anopheles Culex*
Low temperature and moderately high altitudes	*Gambusia affinis*	*Anopheles Culex*

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MALARIA RESEARCH CENTRE

The Malaria Research Centre (MRC) was established in the year 1977. Its primary task was to find short-term as well as long-term solutions to the problem of malaria through basic, applied and field operational research. The Centre is currently doing work in the areas of vector biology and control, genetics, cellular and molecular biology, parasitology, epidemiology, pharmacology and biochemistry, that is related to malariology and the development of malaria control strategies. A network of field laboratories in endemic areas provides the testing ground for new technologies and innovative approaches, and helps in the transfer of technology through training, field demonstrations and mass awareness programmes involving various media. The Centre also provides young scientists the opportunity to participate in advanced research through a fellowship programme. Close links in the form of scientific collaborations are maintained with WHO, NMEP and also leading national laboratories. Research findings of the Centre are published in reputed journals. Apart from this, the Centre publishes several books, monographs, proceedings including the Indian Journal of Malariology.